6 3 - 2 - 6

MEMORANDUM REPORT
M63-24-1

UNITED STATES ARMY

FRANKFORD ARSENAL

HUMAN FACTORS EVALUATION OF FUZE SETTING FOR FUZE, MTSQ, T197E2

by

E. J. McGuigan

OMS 5530.12.542
DA Project 505-02-022

REPORT M63-24-1

February 1963

PHILADELPHIA 37, PA.

Frankford Arsenal
Philadelphia 37, Pa.

Memorandum Report M63-24-1
February 1963
OMS 5530.12.542
DA Project 505-02-022

HUMAN FACTORS EVALUATION OF FUZE SETTING FOR FUZE, MTSQ, T197E2

Prepared by: E. J. McGuigan
E. J. MCGUIGAN
Psychologist

Reviewed by: A. Charles Karr
A. C. KARR
Chief
Human Factors Branch

Approved by: S. M. Lawrence
S. M. LAWRENCE
Associate Director
Research and Development Group

ABSTRACT

An exploratory human factors evaluation of fuze setting for Fuze, MTSQ, T197E2 was conducted to assess the variables involved for possible use in a more comprehensive experiment. Each of the 15 subjects completed 120 settings for a total of 1800 settings. Error incidence in the laboratory study was high in comparison with reported field results. Recommendations are made for a more definitive field study.

TABLE OF CONTENTS

INTRODUCTION

The immediate purpose of this experiment was to uncover and define the human factor variables involved in setting the T197E2 fuze. This was based upon the hypothesis that human error was responsible for a single shell malfunction out of a total of 515 rounds fired in the fuze service test at Ft. Greely, Alaska. The shell had been scheduled to burst at the 3.5 seconds position (fig. 1), but actually fired at the 1.5 seconds position (fig. 2). The theory advanced was that the person setting the fuze may have inadvertently confused the "S" (Safe) position (fig. 3) with the "O" (Zero) position (fig. 4). Since these positions are two seconds apart, a logical basis existed for explaining the malfunction. An informal preliminary study, done with available personnel and confined to the "critical" area around the 3.5 seconds position, supported the hypothesis. Two of the six subjects confused the "S" and "O" positions until the error was pointed out to them. The present study was undertaken to establish the legitimacy of the hypothesis and to extract the relevant factors involved for possible use in a more comprehensive experiment.

PROCEDURE

Fifteen enlisted male personnel assisted in the experiment. All of them had varying degrees of experience with the setting of vernier scales, the principle involved in setting the fuze. Each subject was given a refresher briefing and demonstration of the principle and then given a chance to set the fuze until he had attained the desired criterion of proficiency--three consecutive correct settings. Subjects were told their scores after completion of their part in the experiment, but were cautioned not to discuss the experiment with other subjects in order to prevent contamination of the study.

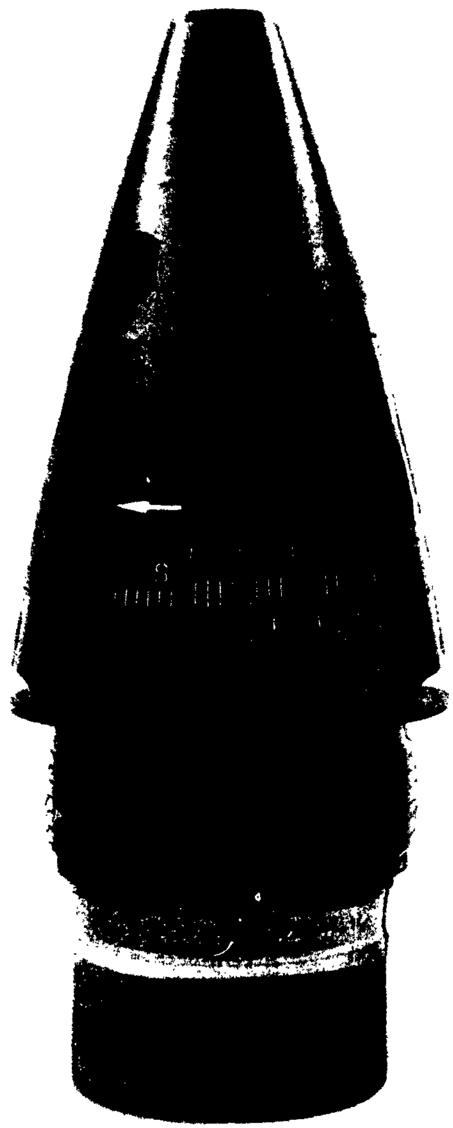
Figure 1.

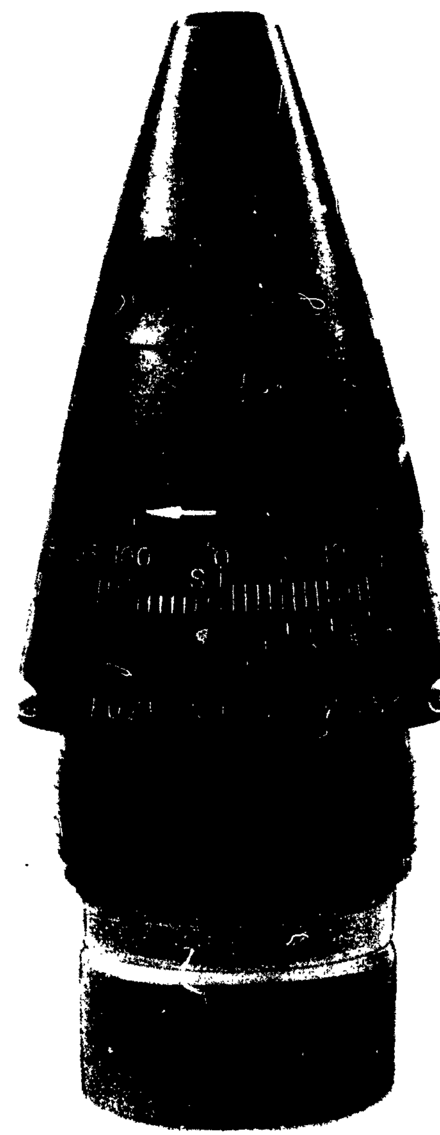
Figure 2.

Figure 3.

Figure 4.

The fuze consists of head, lower cap, and body. Only the latter two were pertinent for the experiment. The lower cap contains the main scale, numbering from one to one hundred, with each scale graduation representing an interval of one second. The body contains the vernier scale for measuring time increments of one-tenth of a second. The experimenter initially set the fuze on the "S" setting, two graduations below the "O" setting from which the fuze is set. After being told the number to be set, the subject using a fuze setting wrench rotated the lower cap clockwise until the proper setting had been made.

Two fuzes were used in the experiment. Each fuze was attached to a 155mm shell which was rigidly emplaced in a wooden box at an angle of approximately 60 degrees. The subject faced the head of the fuze while setting it (fig. 5) although the method used will vary for different types of shell or for various tactical situations. The wooden boxes were placed twenty feet apart and the subject alternately set each fuze. This gave the experimenter time to record data and to reset the fuze to the "S" position for the next trial. Each setting was timed (the timing element was injected to determine what effect this variable might have on the study). Subjects were told that the timing would have no direct relationship with the experiment but would provide a measure of the relation between error and time. They were then told to work as quickly and accurately as possible, but to place emphasis on accuracy.

EXPERIMENTAL DESIGN

A simple experimental design was employed. Each of the fifteen subjects completed a total of 120 settings in three equal increments of 40. A five minute rest period was given after each 40 settings. Since the error in the service test theoretically occurred in the 3.5 seconds area of the scale, the range of settings purposely included this point, as well as a sufficient portion of the upper scale to insure adequate coverage of other possible trouble areas. Additionally, the range was made large and varied enough to prevent subject insight concerning the "critical" area.

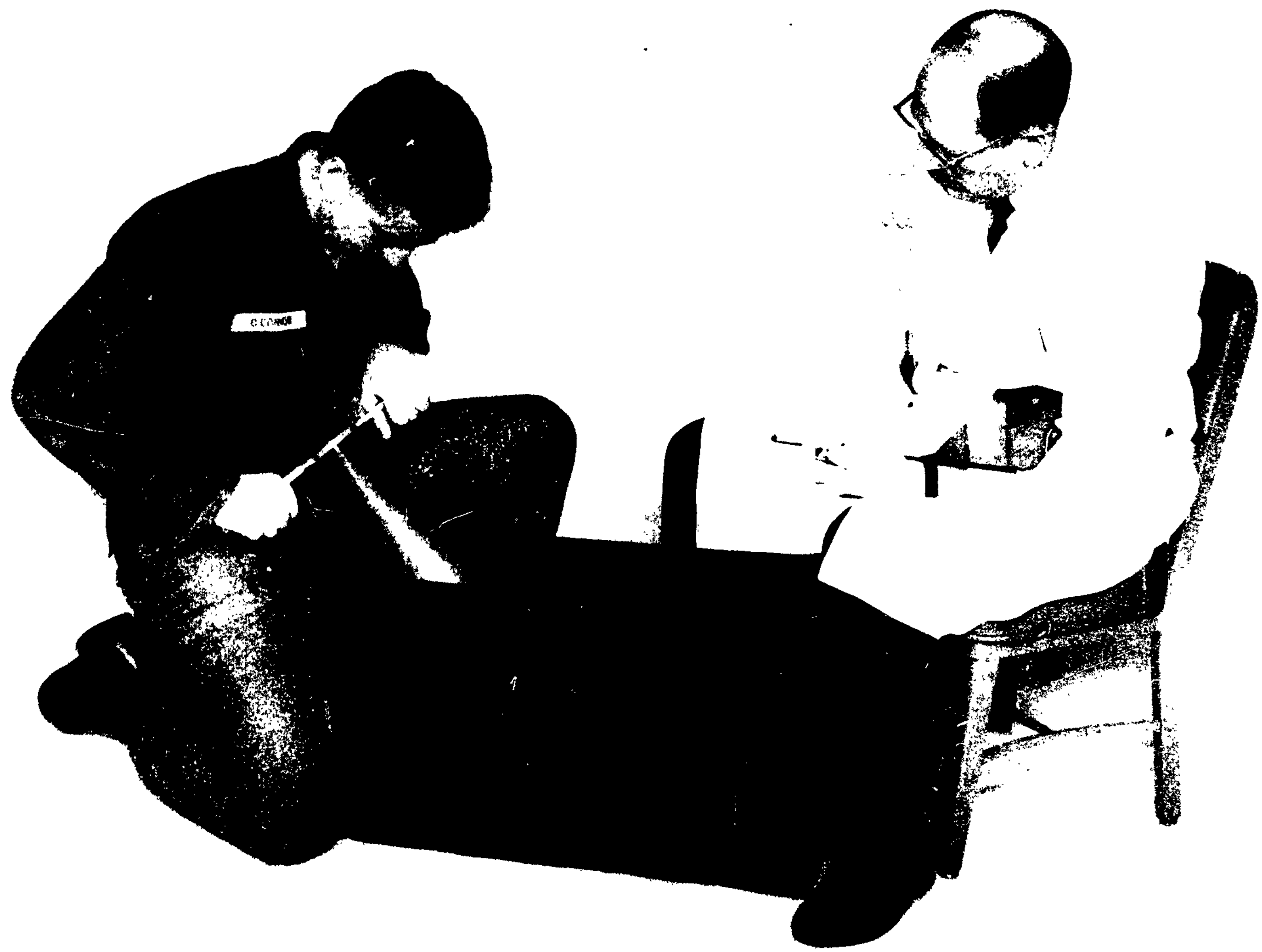

Figure 5. Setting of Fuze, MTSQ, T197E2 with Fuze Setting Wrench

An error was arbitrarily defined as a setting which varied more than 0.5 seconds from the setting requested by the experimenter. This relatively large error tolerance was dictated by the inherent error in the fuzes (the lines on the body and lower cap were in some cases as much as 0.2 seconds off from perfect alignment) and by the expected judgment differences in the interpretation of vernier settings by experimenter and subject. A number of subjects made two or three passes before coming up with the correct setting, but this was not considered an error since they had merely overshot the correct setting and were fully aware of the discrepancy.

RESULTS

Table I lists subject errors in order of magnitude. They range from 0 errors for six of the subjects to a maximum of 10 for one individual. Total settings, total errors, and total error percentage (39 errors out of a total of 1800 settings) are also included.

Table II lists the ranges of the requested settings, the requested settings, the error settings, and the error percentage (out of a total of 39 errors) for each of the ranges sampled.

Table I. Subject Errors Arranged in Order of Magnitude
(120 Settings per Subject)

Subject	Number of Errors
M	0
F	0
I	0
H	0
C	0
K	0
B	1
D	1
L	2
O	3
E	4
J	4
N	5
G	9
A	10
	Total: 39 Errors

Total Settings: 1800
Total Errors: 39
Error Percentage: 2.2%

Table II.

Range	Requested Setting	Error Setting	Error Percentage for Each Range (Total 39 Errors)
3.2-3.9	3.3	2.3	
	3.4	2.4	
	3.6	2.6	
	3.7	2.7	
	3.9	2.9	
	Total	5	12.56%

Table II. (Cont'd)

Range	Requested Setting	Error Setting	Error Percentage for Each Range (Total 39 Errors)
7.0-7.9	7.8	6.8	
	7.9	6.9	
	7.8	*8.8	
	Total	3	7.69%
14.0-14.9	14.3	13.3	
	14.6	13.6	
	14.8	13.8	
	14.8	13.8	
	14.8	13.8	
	14.9	13.9	
	14.9	13.9	
	14.9	13.9	
	Total	8	20.51%
18.2-18.9	18.4	17.4	
	18.8	17.8	
	18.9	17.9	
	18.9	17.9	
	18.9	17.9	
	18.9	17.9	
	18.9	17.9	
	18.9	17.9	
	Total	8	20.51%

*Errors in which the subject responded with a digit one higher than the given digit. The balance of responses were one digit less than the given digit.

Table II. (Cont'd)

Range	Requested Setting	Error Setting	Error Percentage for Each Range (Total 39 Errors)
23.0-23.9	23.2	22.2	
	23.2	22.2	
	23.3	22.3	
	23.4	22.4	
	23.4	22.4	
	23.5	22.5	
	23.6	22.6	
	23.7	22.7	
	23.9	22.9	
	23.9	22.9	
	23.9	22.9	
	23.9	22.9	
	23.9	22.9	
	23.4	*24.4	
	23.1	*24.1	
	Total	15	38.46%

*Errors in which the subject responded with a digit one higher than the given digit. The balance of responses were one digit less than the given digit.

DISCUSSION

Error size remained consistently at the 1.0 second level. Subjects when making an error tended to give the next lowest whole digit (36 out of 39), with three of the errors falling in the opposite direction. The magnitude of the total errors (39 errors out of a total of 1800 settings) is extremely high when compared with the single error encountered in the service test (515 settings). This disparity is more emphatic when it is taken into consideration that experimental conditions were optimal in comparison with those ordinarily encountered in the field. A possible explanation of this is the fact that normal safety procedures in a service test require a check of the setting by the range officer or some other responsible person.

While inspection of table II shows that the majority of errors fell at the upper area of the scale, this does not negate the original hypothesis. There is no assurance that the five errors made in the "critical" area were not due to the confusion of the "S" and "O" positions, particularly for settings between 0 and 5. Beyond the 5 seconds point, the situation changes radically and becomes another problem. For example, in making a 23.4 setting, the fuze setter would normally move quickly to the 20 mark and, using this as his reference point, make the final 23 and .4 settings. The point to be stressed is that not only are there differences in the occurrence of errors, but there may be different causative agents for errors at very low settings and those in the higher ranges of the scale.

There was no correlation between time and error. Some of the faster individuals made no errors while some of the slower ones made more than the average number of errors. The most significant pattern found in the study was the high variation in individual performance. When subjects of relatively equal ability vary as much as they did in the present experiment (6 subjects made no errors while 2 of the subjects made 9 and 10 errors, respectively), some explanation of the variance must be sought. A partial listing of sources of subject error variance would include: reaction to stress, motivation, carelessness, confidence, emphasis on speed rather than accuracy and the whole gamut of individual differences found in any test situation.

CONCLUSIONS AND RECOMMENDATIONS

There were two significant conclusions resulting from the experiment: (1) the occurrence of errors in the "critical" area as well as cursory inspection of the Zero/Safe positions indicates that the possibility of error caused by the confusion of these two positions cannot be ruled out, particularly at low settings and under conditions of stress, (2) there is at present little or no valid information available to the fuze designer concerning the human factor variables involved in fuze setting.

The first problem could be handled fairly easily by a minor redesign of the Safe/Zero position based on experimental evidence. Several alternative designs could be developed and, using the present design as a criterion, selection would be made on the basis of error incidence in the study.

The second problem is much more extensive in scope. It would necessarily involve a comprehensive and definitive study to extract the human factor variables involved in fuze setting to enable the designer to anticipate and eliminate troublesome areas in the concept stage. The format for such a study would cover two phases: (1) an exploratory study to uncover and define the human factors involved, (2) resolution of present problems by minor changes in equipment (e.g. the Safe/Zero positions previously mentioned) where feasible. Future problems would, of course, be handled in the concept stage.

The exploratory study would have to be conducted under field conditions. It would be extremely difficult and costly to duplicate field conditions in the laboratory and there would be no assurance that the simulated conditions would give a valid picture of problems as they are in the field. The study would have to be extensive enough to include all of the major environmental and tactical situations encountered under combat conditions. Among others, these would include: arctic and tropical conditions; various levels of illumination; stress conditions such as weapons firing; weather conditions such as rain, snow, or fog; and equipment and clothing (such as arctic mittens, goggles, etc.) which might affect performance.

Personnel selection and training methods would be an additional area for investigation. The wide variation in individual performance in the present study would normally be expected in an unselected population, but the personnel used were a select group of science and engineering personnel which should have kept variation at minimal levels. This may indicate that selection of personnel will have to take into account such factors as reaction to stress, carelessness, and accident-proneness. Investigation of current methods of training and application of available psychological principles of learning could also be carried out. There may be occasions when the fuze designer has no other alternative to using a design which will impose an extra burden on the human component in the system. Improved training methods can help overcome conditions such as this and minimize error due to human factors.

DISTRIBUTION

1 - Headquarters
U. S. Continental Army Command
Fort Monroe, Virginia

2 - Headquarters
U. S. Army Materiel Command
Washington 25, D. C.
Attn: AMCRD-DE-MO

1 - Commanding Officer
Harry Diamond Labs
Washington 25, D. C.

1 - Attn: Tech Ref Section

1 - Commanding Officer
U. S. Army Test and Evaluation Command
Aberdeen Proving Ground
Maryland

5 - Commanding Officer
U. S. Army Human Engineering Lab
Aberdeen Proving Ground
Maryland
Attn: AMXHE
Dr. John D. Weisz

3 - Commanding Officer
U. S. Army Munitions Command
Picatinny Arsenal
Dover, New Jersey
Attn: Human Engineering Section, SMUPA-VC1
Mr. Paul Strauss

1 - Commanding Officer
U. S. Army Missile Command
Huntsville, Alabama

1 - Commanding Officer
U. S. Army Artillery Board
Fort Sill, Oklahoma

1 - Commanding Officer
U. S. Army Air Defense School
Fort Bliss, Texas

1 - Commanding Officer
Rossford Army Depot
Toledo, Ohio

1 - Commanding Officer
U. S. Army Weapons Command
Rock Island, Illinois

1 - Commanding Officer
Yuma Test Station
Arizona

1 - Commanding Officer
U. S. Army Ammunition Procurement-Supply Agency
Joliet, Illinois

10- Armed Services Technical Information Agency
Arlington Hall Station
Arlington, Virginia
Attn: TIPDR

AD- M63-24-1 ACCESSION NO.	UNCLASSIFIED
Frankford Arsenal, Philadelphia 37, Pa. HUMAN FACTORS EVALUATION OF FUZE SETTING FOR FUZE, MTSQ, T197E2 by E. J. McGuigan Memorandum Report M63-24-1, February 1963, 13 pp incl tables (DA Project 505-02-022, OMS 5530.12.542) UNCLASSIFIED REPORT An exploratory experiment was conducted to define the human factor variables involved in setting the T197E2 fuze. Fifteen subjects completed a total of 120 settings in increments of 40 for a total of 1800 settings. Error incidence in this laboratory study was high in comparison with reported field results. Recommendations are made for a more definitive field study.	1. Fuze Setting 2. Fuze, MTSQ, T197E2 I. E. J. McGuigan II. OMS 5530.12.542 DISTRIBUTION LIMITATIONS: Qualified requesters may obtain copies of this report from ASTIA. UNCLASSIFIED

AD- M63-24-1 ACCESSION NO.	UNCLASSIFIED
Frankford Arsenal, Philadelphia 37, Pa. HUMAN FACTORS EVALUATION OF FUZE SETTING FOR FUZE, MTSQ, T197E2 by E. J. McGuigan Memorandum Report M63-24-1, February 1963, 13 pp incl tables (DA Project 505-02-022, OMS 5530.12.542) UNCLASSIFIED REPORT An exploratory experiment was conducted to define the human factor variables involved in setting the T197E2 fuze. Fifteen subjects completed a total of 120 settings in increments of 40 for a total of 1800 settings. Error incidence in this laboratory study was high in comparison with reported field results. Recommendations are made for a more definitive field study.	1. Fuze Setting 2. Fuze, MTSQ, T197E2 I. E. J. McGuigan II. OMS 5530.12.542 DISTRIBUTION LIMITATIONS: Qualified requesters may obtain copies of this report from ASTIA. UNCLASSIFIED

AD- M63-24-1 ACCESSION NO.	UNCLASSIFIED
Frankford Arsenal, Philadelphia 37, Pa. HUMAN FACTORS EVALUATION OF FUZE SETTING FOR FUZE, MTSQ, T197E2 by E. J. McGuigan Memorandum Report M63-24-1, February 1963, 13 pp incl tables (DA Project 505-02-022, OMS 5530.12.542) UNCLASSIFIED REPORT An exploratory experiment was conducted to define the human factor variables involved in setting the T197E2 fuze. Fifteen subjects completed a total of 120 settings in increments of 40 for a total of 1800 settings. Error incidence in this laboratory study was high in comparison with reported field results. Recommendations are made for a more definitive field study.	1. Fuze Setting 2. Fuze, MTSQ, T197E2 I. E. J. McGuigan II. OMS 5530.12.542 DISTRIBUTION LIMITATIONS: Qualified requesters may obtain copies of this report from ASTIA. UNCLASSIFIED

AD- M63-24-1 ACCESSION NO.	UNCLASSIFIED
Frankford Arsenal, Philadelphia 37, Pa. HUMAN FACTORS EVALUATION OF FUZE SETTING FOR FUZE, MTSQ, T197E2 by E. J. McGuigan Memorandum Report M63-24-1, February 1963, 13 pp incl tables (DA Project 505-02-022, OMS 5530.12.542) UNCLASSIFIED REPORT An exploratory experiment was conducted to define the human factor variables involved in setting the T197E2 fuze. Fifteen subjects completed a total of 120 settings in increments of 40 for a total of 1800 settings. Error incidence in this laboratory study was high in comparison with reported field results. Recommendations are made for a more definitive field study.	1. Fuze Setting 2. Fuze, MTSQ, T197E2 I. E. J. McGuigan II. OMS 5530.12.542 DISTRIBUTION LIMITATIONS: Qualified requesters may obtain copies of this report from ASTIA. UNCLASSIFIED

UNCLASSIFIED

UNCLASSIFIED